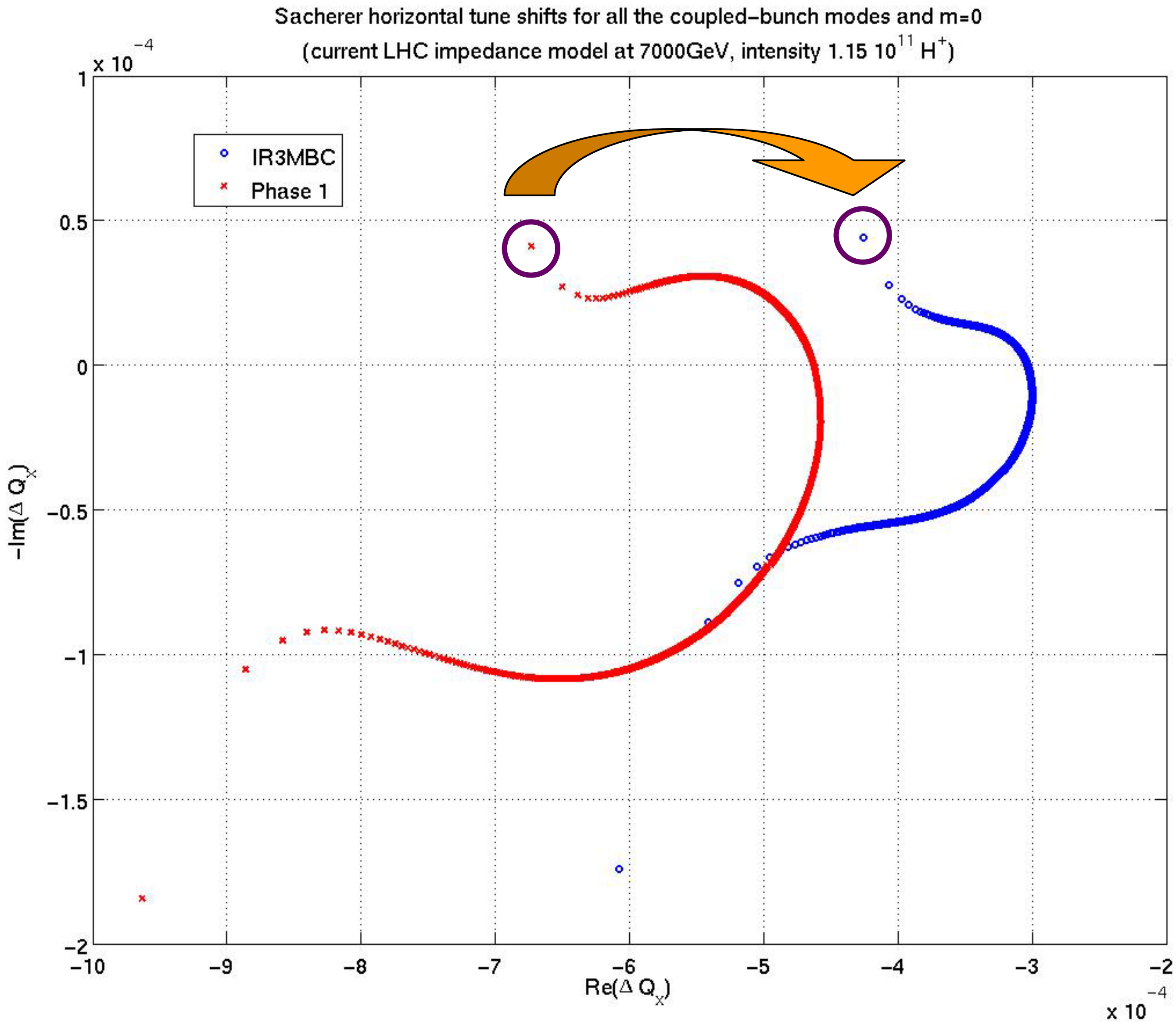
LHC impedance and multibunch modes

First comparison between phase 1 and IR3MBC (combined momentum and betatron cleaning in IR3 – settings from A. Rossi)

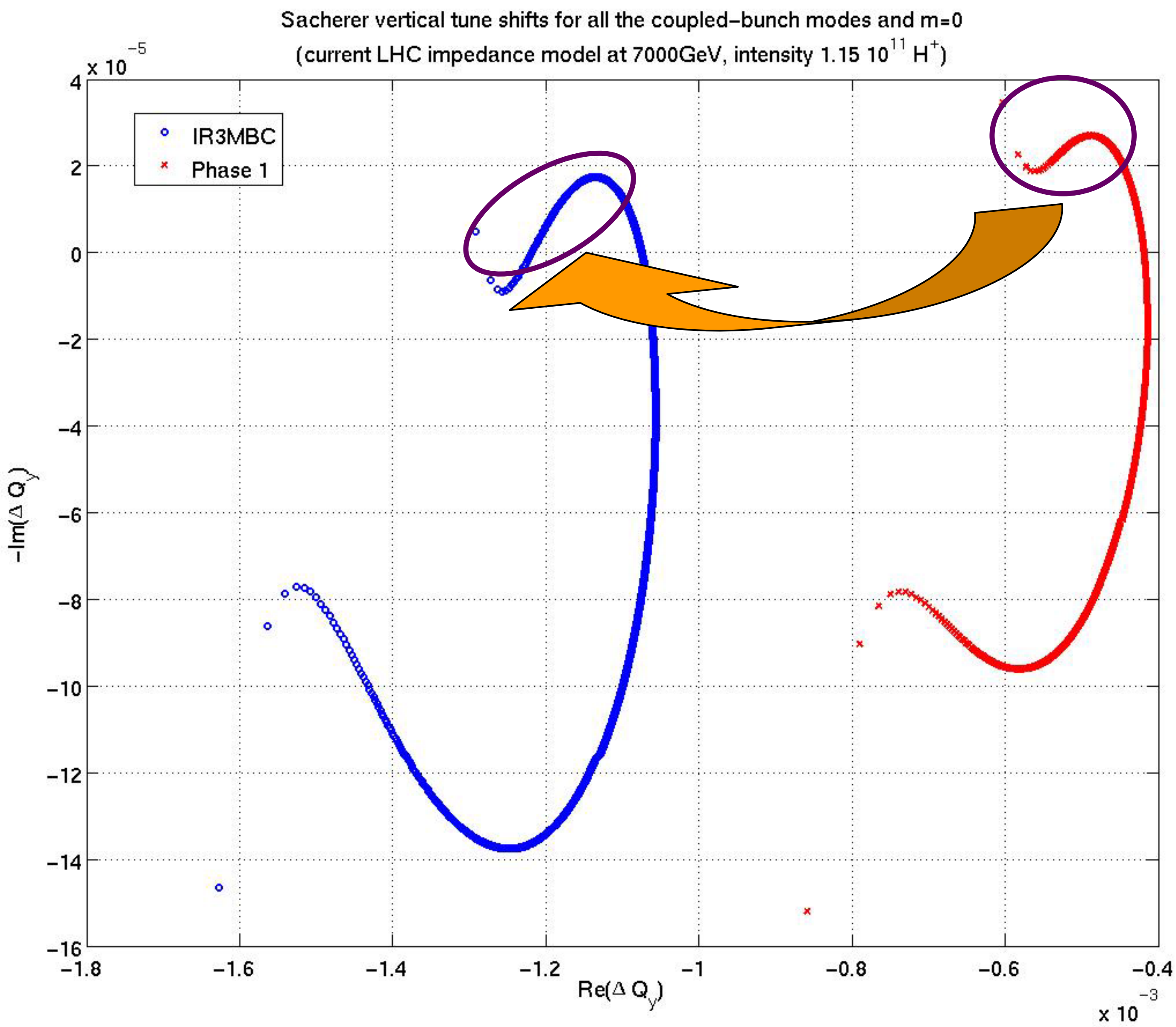
!! Preliminary results !! (some effects, such as temperature, not taken into account)

Multibunch modes: horizontal



Better in horizontal, but…

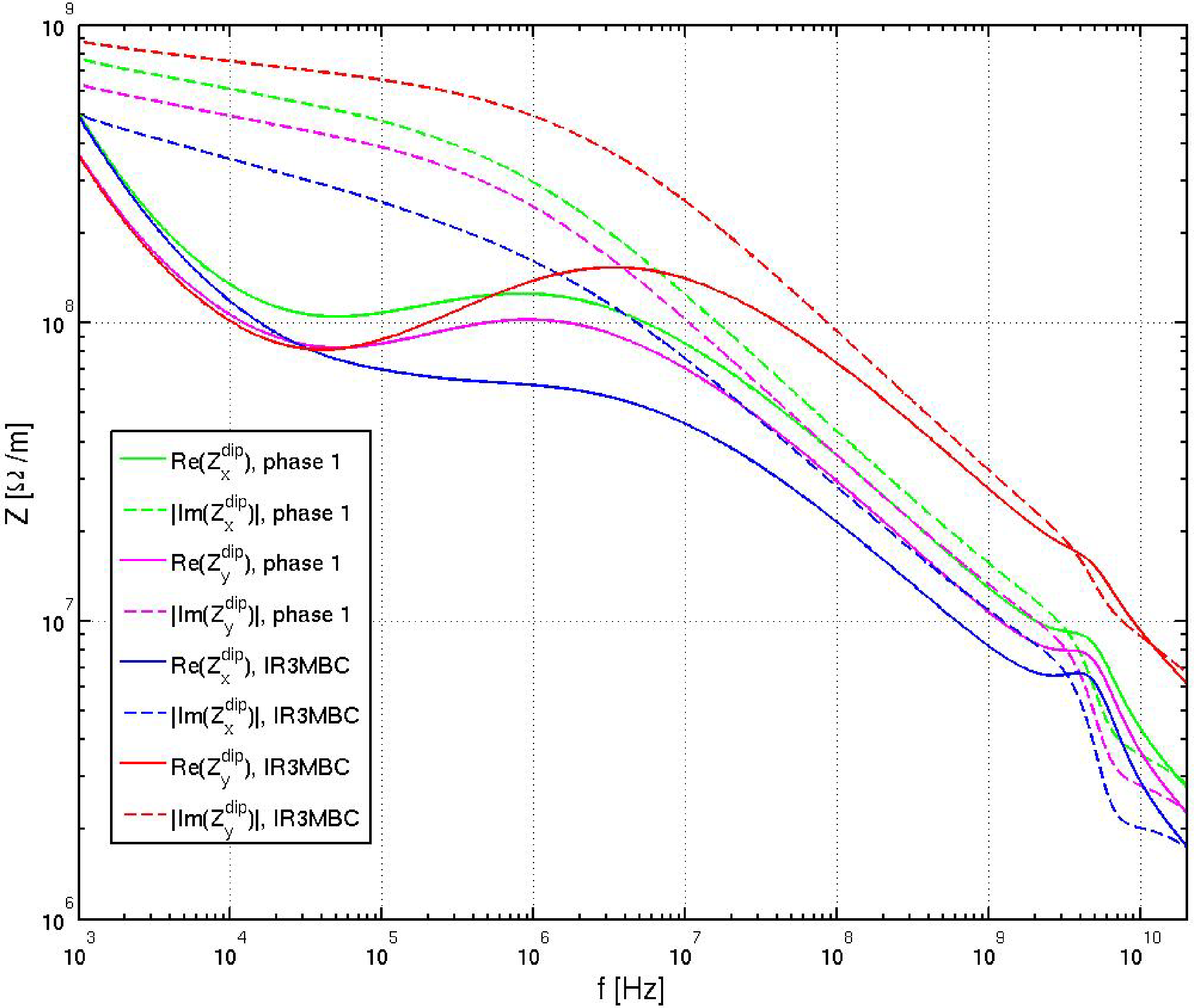
Multibunch modes: vertical



… worse in vertical.

In particular, huge tune shift (~1.3 10^{-3}) with IR3MBC option.

Horizontal and vertical dipolar (driving) impedance



⇒ Confirm a much stronger vertical impedance with IR3MBC w.r.t. phase 1 (red vs.magenta) above ~10^5 Hz)

Largest impedance contributors in IR3MBC configuration

name	Material	Length[m]	s [m]	angle[rad]	betax[m]	betay[m]	halfgap[m]	sigx[m]	sigy[m]	nsig
TCL.5R1.B1	CU	1.00	184.36	0.00	172.29	903.46	2.94E-03	2.94E-04	6.74E-04	10.00
TCTH.4L2.B1	W	1.00	3214.49	0.00	77.92	90.43	1.64E-03	1.98E-04	2.13E-04	8.30
TDI.4L2.B1	CU	4.00	3251.6	1.57	138.58	87.80	1.89E-01	2.64E-04	2.10E-04	900.00
TCTVB.4L2	W	1.00	3258.95	1.57	155.16	91.01	1.78E-03	2.79E-04	2.14E-04	8.30
TCLIA.4R2	C	1.00	3408.18	1.57	89.86	149.70	2.47E-01	2.13E-04	2.74E-04	900.00
TCLIB.6R2.B1	C	1.00	3560.09	1.57	176.59	74.45	1.74E-01	2.98E-04	1.93E-04	900.00
TCP.6L3.B1	C	0.60	6487.67	0.00	131.52	144.70	1.54E-03	2.57E-04	2.70E-04	6.00
TCP.A6L3.B1	C	0.60	6489.27	1.57	126.08	151.38	1.66E-03	2.52E-04	2.76E-04	6.00
TCSG.5L3.B1	C	1.00	6521.99	0.00	54.61	298.63	1.16E-03	1.66E-04	3.87E-04	7.00
TCSG.A5L3.B1	C	1.00	6523.04	1.57	53.48	301.85	2.73E-03	1.64E-04	3.90E-04	7.00
TCSG.4R3.B1	C	1.00	6707.58	0.00	26.21	395.17	8.03E-04	1.15E-04	4.46E-04	7.00
TCSG.B4R3.B1	C	1.00	6709.53	1.57	26.90	389.29	3.10E-03	1.16E-04	4.42E-04	7.00
TCSG.A5R3.B1	C	1.00	6718.92	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TCSG.C5R3.B1	C	1.00	6720.92	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TCSG.B5R3.B1	C	1.00	6724.74	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TCSG.D5R3.B1	C	1.00	6726.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TCLA.A5R3.B1	W	1.00	6755.22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TCLA.B5R3.B1	W	1.00	6757.22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TCLA.6R3.B1	W	1.00	6843.77	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TCLA.7R3.B1	W	1.00	6915.18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TCRYO.AR3.B1	W	1.00	6964.11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TCRYO.BR3.B1	W	1.00	7053.66	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TCTH.4L5.B1	W	1.00	13181.77	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TCTVA.4L5.B1	W	1.00	13183.45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TCL.5R5.B1	CU	1.00	13513.55	0.00	172.71	906.71	2.95E-03	2.95E-04	6.75E-04	10.00
TCDQA.A4R6.B1	C	3.00	16808.52	0.00	495.25	165.46	3.99E-03	4.99E-04	2.88E-04	8.00
TCDQA.B4R6.B1	C	3.00	16812.07	0.00	506.39	169.73	4.04E-03	5.05E-04	2.92E-04	8.00
TCSG.4R6.B1	C	1.00	16815.98	0.00	518.85	174.68	3.83E-03	5.11E-04	2.96E-04	7.50
TCP.D6L7.B1	C	0.60	19789.18	1.57	158.87	78.26	1.79E-01	2.83E-04	1.98E-04	900.00
TCP.C6L7.B1	C	0.60	19791.18	0.00	150.53	82.76	2.48E-01	2.75E-04	2.04E-04	900.00
TCP.B6L7.B1	C	0.60	19793.18	2.22	142.46	87.49	2.09E-01	2.68E-04	2.10E-04	900.00
TCSG.A6L7.B1	C	1.00	19832.68	2.46	39.87	226.93	2.15E-01	1.42E-04	3.38E-04	900.00
TCSM.A6L7.B1	CU	1.00	19834.68	2.49	37.55	236.32	2.13E-01	1.37E-04	3.45E-04	900.00
TCSG.B5L7.B1	C	1.00	19891.91	2.50	159.98	166.51	2.57E-01	2.84E-04	2.89E-04	900.00
TCSM.B5L7.B1	CU	1.00	19893.91	2.47	172.70	156.03	2.60E-01	2.95E-04	2.80E-04	900.00
TCSG.A5L7.B1	C	1.00	19895.91	0.71	185.96	145.93	2.62E-01	3.06E-04	2.71E-04	900.00
TCSM.A5L7.B1	CU	1.00	19897.91	0.75	199.75	136.22	2.64E-01	3.17E-04	2.62E-04	900.00
TCSG.D4L7.B1	C	1.00	19917.24	1.57	332.92	68.86	1.67E-01	4.09E-04	1.86E-04	900.00
TCSM.D4L7.B1	CU	1.00	19919.24	1.57	341.03	65.36	1.63E-01	4.14E-04	1.81E-04	900.00
TCSG.B4L7.B1	C	1.00	19987.16	0.00	139.75	130.98	2.39E-01	2.65E-04	2.57E-04	900.00
TCSM.B4L7.B1	CU	1.00	19989.16	0.00	134.12	136.06	2.34E-01	2.60E-04	2.62E-04	900.00
TCSG.A4L7.B1	C	1.00	19991.16	2.35	128.66	141.28	2.35E-01	2.54E-04	2.66E-04	900.00
TCSM.A4L7.B1	CU	1.00	19993.16	2.37	123.38	146.67	2.34E-01	2.49E-04	2.72E-04	900.00
TCSG.A4R7.B1	C	1.00	19995.16	0.81	118.28	152.21	2.35E-01	2.44E-04	2.77E-04	900.00
TCSM.A4R7.B1	CU	1.00	19997.16	0.79	113.34	157.90	2.35E-01	2.39E-04	2.82E-04	900.00
TCSG.B5R7.B1	C	1.00	20086.42	2.47	121.85	267.55	2.69E-01	2.47E-04	3.67E-04	900.00
TCSM.B5R7.B1	CU	1.00	20088.42	2.44	131.77	252.23	2.72E-01	2.57E-04	3.56E-04	900.00
TCSG.D5R7.B1	C	1.00	20102.42	0.90	213.87	158.53	2.71E-01	3.28E-04	2.82E-04	900.00
TCSM.D5R7.B1	CU	1.00	20104.42	0.93	227.41	147.07	2.68E-01	3.38E-04	2.72E-04	900.00
TCSG.E5R7.B1	C	1.00	20106.42	2.28	241.40	136.10	2.71E-01	3.48E-04	2.62E-04	900.00
TCSM.E5R7.B1	CU	1.00	20108.42	2.24	255.83	125.61	2.68E-01	3.59E-04	2.51E-04	900.00
TCSG.6R7.B1	C	1.00	20141.02	0.01	335.75	47.36	3.70E-01	4.11E-04	1.54E-04	900.00
TCSM.6R7.B1	CU	1.00	20143.02	0.01	324.52	47.37	3.63E-01	4.04E-04	1.54E-04	900.00
TCLA.A6R7.B1	W	1.00	20148.09	1.57	297.06	48.16	1.40E-01	3.86E-04	1.56E-04	900.00
TCLA.B6R7.B1	W	1.00	20178.96	0.00	159.49	76.39	2.55E-01	2.83E-04	1.96E-04	900.00
TCLA.C6R7.B1	W	1.00	20212.51	1.57	68.61	151.89	2.49E-01	1.86E-04	2.76E-04	900.00
TCLA.D6R7.B1	W	1.00	20214.51	0.00	65.04	157.92	1.63E-01	1.81E-04	2.82E-04	900.00
TCLA.A7R7.B1	W	1.00	20231.86	0.00	64.26	147.41	1.62E-01	1.80E-04	2.72E-04	900.00
TCTH.4L8.B1	W	1.00	23197.43	0.00	46.99	48.35	1.28E-03	1.54E-04	1.56E-04	8.30
TCTVB.4L8	W	1.00	23241.89	1.57	128.41	52.41	1.35E-03	2.54E-04	1.62E-04	8.30
TCTH.4L1.B1	W	1.00	26511.36	0.00	1574.90	602.24	7.38E-03	8.90E-04	5.50E-04	8.30
TCTVA.4L1.B1	W	1.00	26513.04	1.57	1581.00	635.84	4.69E-03	8.91E-04	5.65E-04	8.30

Settings from A. Rossi

name	Mat	Length[m]	angle[rad]	betax[m]	betay[m]	halfgap[m	nsig
TCSG.4R3.B1	C	1.00	0.00	26.21	395.17	8.03E-04	7.00
TCSG.A5R3.B1	C	1.00	2.98	35.87	344.08	1.04E-03	7.00
TCSG.B5R3.B1	C	1.00	0.20	45.54	312.65	1.17E-03	7.00
TCSG.5L3.B1	C	1.00	0.00	54.61	298.63	1.16E-03	7.00

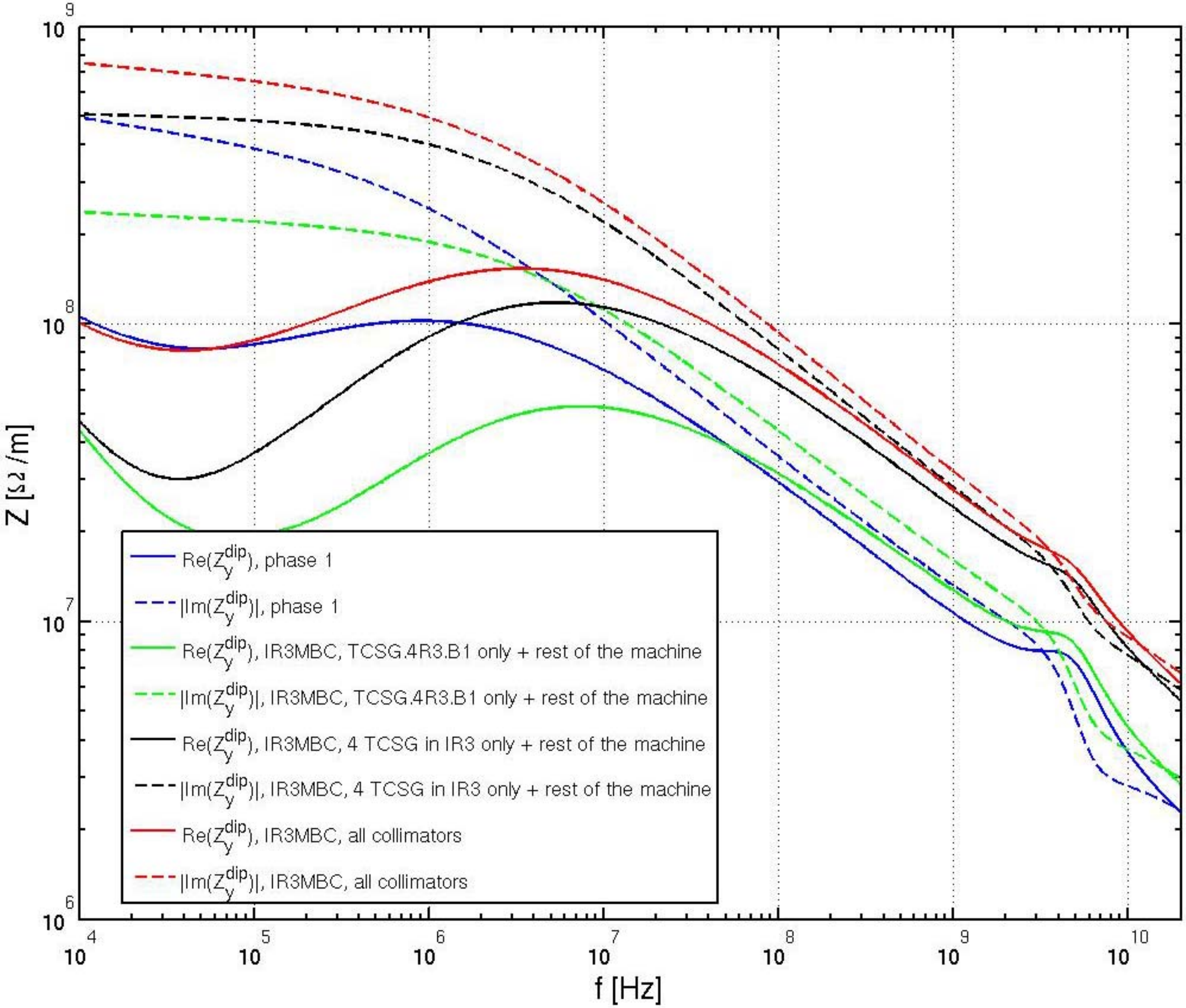
For those horizontal collimators:

- very small halfgap due to small σ (from small β_x),

- quite large β_y,

$\Rightarrow$ **Large vertical impedance** (but not horizontal since β_x is 10 times smaller).

Vertical dipolar impedance: largest contributors



Rest of the machine = everything that is not a collimator in the current impedance model

⇒ Above a few MHz, one single IR3MBC collimator gives the same imag. part as the totality of the phase 1 collimators.

Conclusions

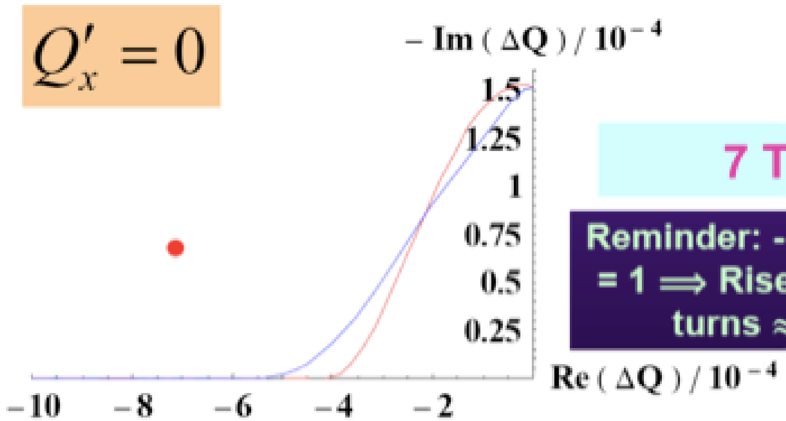
- At 7TeV, with the IR3MBC option, the horizontal impedance is lower than in phase 1, but the vertical one is much larger (for the imaginary part, factor between 1.5 at 10kHz and 3 at 10 GHz).

- In consequence, the multibunch transverse instability (thought to be the most critical effect at 7TeV) is a more critical issue than in phase 1 (well beyond the stability diagram).

- Also, the tune shift is very large $\Rightarrow$ could trigger other problems ?

- The effect on single-bunch stability of such an impedance could be even worse since the factor between IR3MBC and phase 1 increases at high frequency $\Rightarrow$ Headtail simulations to check this are planned .

Reminder: stability diagram (from Elias Métral's previous presentation at CWG on June 7th, 2010)



7 TeV/c

Reminder: - Im (ΔQ) / 10^{-4} = 1 $\Longrightarrow$ Rise time ≈ 1600 turns ≈ 140 ms